EFFECTS OF HIGH AND LOW FREQUENCY DIFFERENTIALS ON VERBAL DISCRIMINATION LEARNING

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THESIS

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ABSTRACT

Two experiments were conducted to examine the effects of two background frequency differentials on verbal discrimination learning. Two 16 item word lists were constructed. In the high differential (HD) list were word pairs in which the relative background frequency of the two words in each pair was at least 5 to 1. The low differential (LD) list was made up of word pairs in which the frequency differential was 2 to 1 or less. The experiments investigated the difference in learning rates between the HD and LD conditions. High frequency word correct (HL) and low frequency word correct (LH) conditions were also examined. Results were evaluated not only on the number of correct responses, but also on the uncertainty remaining after each trial. The HD condition was found to be easier to learn than the LD at the .10 level of significance; the HL condition was significantly easier than the LH at the .05 level. Overall, the background frequency of words influenced VD learning such that learning appeared to be faster with HD word pairs in which the H word had been designated as correct.

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I. INTRODUCTION

Several experiments in the past have shown that S's are able to accurately rank letters and words according to their relative frequency of useage in the English Language. Attneave (1953) showed that a significant correlation exists between the actual frequency of occurrence of letters and the S's judgement of their frequency of occurrence. Shapiro (1969) showed that S's could rank words effectively using two separate subjective scaling techniques, magnitude estimation and multiple rank orders. These and other studies (Ekstrand, Wallace, and Underwood 1966, Underwood and Freund 1968, Kausler and Farzanegan 1969) have established that the difference in frequency of occurrence of words is an important cue upon which verbal discrimination (VD) learning takes place.

Background frequency of occurrence as opposed to the experimental frequency that is built up during repeated runs of verbal discrimination lists, is one of the criteria that can be used by S's in making their initial guess at the correct item of a VD pair. If there were a high frequency differential (HD) between the words in the pair, then frequency theory says that the S would tend to pronounce the higher word as being his choice as the correct one. However, if the frequency differential were low (LD), then the S might not be able to distinguish between the two words and his guess would have to be made on some other basis. Thus his first choice would be random as far as frequency theory was concerned.

For this paper, the more frequent word in a verbal discrimination pair will be designated by H and the less frequent word by L. HL indicates a VD pair in which the H word is the correct response and LH indicates the converse. LH-HL indicates a pair wherein both the H word and the L word have an equal probability of being the correct response.

In order to help explain the way an S would select a response word, Ekstrand et al. (1966) proposed two rules for VD learning. Rule 1 says, "always select the more frequent of the two units in a pair," and Rule 2 says, "always guess the less frequent of the two units in a pair." It has been shown in the past that these two rules are efficient when applied to HL lists or LH lists respectively. Neither rule can be applied to LH-HL lists and it has been found that such lists are significantly more difficult to learn than either HL or LH lists.

Kausler and Farzanegan (1969) were one of the first groups to investigate HL, LH, and LH-HL verbal discrimination learning using background word-frequency differentials as a variable in intraitem discrimination. For their experiment, they used lists of 12 word pairs and found that mean number of trials to criterion for the lists were: HL 4.92 (SD=1.88), LH 5.50 (SD=2.71), and HL-LH 9.17 (SD=3.90). This elicited some surprise that the HL and LH lists were not learned even faster. Two hypotheses were put forth as possible explanations: (1) "idiosyncratic differences in the subjective frequencies of the L and H frequency words comprising the

words, thereby diminishing somewhat the effectiveness of the general selection strategies", and (2) S's were not aware of any systematic classification of correct and incorrect responses because rule behavior applies only at the level of individual pairs.

The basic findings of Kausler and Farzanegan were duplicated by Nappi (1971). In analyzing his experiment, Nappi also discovered a sharp rise in correct responses to the LH list after the third trial. This increase resulted in parity of the HL and LH lists on the fourth trial whereas on the first three trials, the HL list had been more efficient. Final results of trials to criterion had the HL list slightly more efficient than the LH list, but not significantly so. Analysis of this sudden and unexpected jump of correct responses in the LH list was not within the scope of Nappi's treatise and no possible explanation was offered.

Examination of past VD experiments revealed that it was assumed in most of them that words would be chosen as correct on the first trial in a random manner. Thus, the choice of an H or an L word would be equally likely. Considering Nappi's experiment, where it appears that Rule 1 is more efficient on the first few trials, it seems illogical that L words would be picked as frequently as H words on the first trial.

In addition to examining the role of differences in background frequency in VD learning, this study also investigated the application of information theory for the quantification of VD learning tasks and VD learning performance.

Using information theory, the data collected from VD experiments can be analyzed in terms of bits of uncertainty remaining, or joint uncertainty U(x,y). As the S increases the number of correct responses on succeeding trials, the uncertainty remaining in the list will be reduced. Joint uncertainty, as given by Garner (1962), is defined as,

$$U(x,y) = -\sum p(x,y) \log_2 p(x,y),$$

where p(x,y) is the joint probability of x and y. Table 1 shows the bits of uncertainty remaining as a function of the number of correct responses when the number of items is 16 and the high or low frequency number has been consistently designated as correct, i.e., an HL or LH condition, but not HL-LH.

TABLE 1

JOINT UNCERTAINTY FOR 16 ITEM LIST OF HL OR LH TYPE

PERMUTATION OF CHOICES		JOINT UNCERTAINTY
RIGHT (WRONG)	WRONG (RIGHT)	U(x,y)
0	16	0.0000
1	15	5.2384
2	14	8.6960
3	13	11.2224
4	12	12.9808
5	11	14.2912
6	10	15.2704
7	9	15.8320
8	8	16.0000

It should be noted that joint uncertainty does not vary for identical permutations of right and wrong. Whether an S gets one correct response and 15 incorrect or 15 correct and one incorrect, the uncertainty remaining is exactly the same.

In this study two separate experiments were conducted, the first to gather the data necessary to obtain valid results on the second. Experiment 1 had a two-fold purpose, (1) to determine with what percentages the S's would choose H or L words on the first trial and (2) to empirically determine frequency differentials in selected word pairs so that the Thorndike and Lorge (1944) count might be updated to 1973 standards. Experiment 2 was designed (1) to examine the learning differential that might exist between lists of high differential (HD) words and lists of low differential (LD) words, and (2) to examine the sudden increase in correct responses to the LH list that was evidenced in Nappi's experiment.

II. EXPERIMENT 1

A. METHOD

1. Word Lists

Two master word lists were constructed using words from the category norms compiled by Battig and Montague (1969). Only words of one or two syllables were taken into consideration for possible use in the master lists. The frequency of occurrence for each word selected was obtained from the Thorndike and Lorge (1944) count. A total of 179 pairs were formed and the frequency ratio between the two words in each pair was calculated. In order to control for intrapair similarity, each pair was composed of words from the same Battig and Montague category.

All word pairs with a frequency ratio of greater than 2 to 1 and less than 5 to 1 were then eliminated from further consideration. The pairs with ratios 5 to 1 or greater were designated the high differential (HD) group and the pairs with ratios 2 to 1 or less, the low differential (LD) group. Twenty-five pairs were selected from each group to make up the two master lists using the following rules. Words in the master lists all had a frequency count of at least 4 in Thorndike and Lorge. In addition, words with strong double meanings, words whose meanings were thought to have changed radically in the past few years, and words whose

frequencies have been affected by recent issues were not used. Table 2 shows both the HD master list and the LD master list.

2. Subjects

The 44 subjects were graduate level students at the U.S. Naval Postgraduate School. The experiment was conducted as a classroom exercise in three management courses.

3. Procedure

The two master lists were combined to form one 50 item list. The sequencing of HD and LD pairs in the lists and the positioning of the correct response in each pair were randomized twice, once for part 1 of the experiment and once for part 2. The task for the S in part 1 was to pick the word in each pair which he thought the experimenter had previously chosen as the correct one. The task in part 2 was for the S to subjectively rank the words in each pair according to what he thought were their relative frequencies of usage in the English language. Appendix A contains the actual instructions read to the subjects. Part 1 of the experiment was completed by all S's before work on part 2 was begun. The S's worked independently with no time constraint and each S entered his answers in a pamphlet provided by the experimenter.

B. RESULTS

In analyzing the results of experiment 1, it was noted that three of the 44 S's participating had picked the first word in each pair as being correct every time. Consequently

TABLE 2

MASTER LISTS OF HD WORD PAIRS AND LD WORD PAIRS

HD		LD	
H	L	H	L
pearl	jade	lawyer	banker
hour	era	nail	bench
mile	meter	foot	nose
ale	sherry	velvet	canvas
journal	essay	tin	ore
sugar	spices	copper	carbon
murder	treason	cabin	barn
snow	gale	peach	pear
porch	lobby	chair	lamp
juice	malt	maple	elm
eagle	falcon	lily	daisy
boat	sled	bean	rice
balloon	crayon	cliff	cave
ferry	sailboat	wood	water
boots	sandals	priest	bishop
cotton	tweed	sauce	herbs
pan	saucer	mayor	sheriff
church	shrine	chain	whip
grape	melon	sword	spear
bee	moth	mirror	couch
dog	moose	temple	chapel
poem	poster	deer	fox
hair	wrist	bronze	zinc
tent	shack	wife	aunt
oil	steam	ruby	opal

these were eliminated from the data of part 1. Forty-one good data samples remained for part 1 while part 2 still had 44.

Tables 3 and 4 contain the summarized results of experiment 1 in ratio form. To establish the ratios, the less frequent word according to the Thorndike and Lorge count was given a value of 10 and the higher frequency word a value corresponding to its relative frequency with the lower word. The data from part 2 of the experiment was designed to be in this form in order to facilitate comparisons of individual pairs. The number of times each word was chosen as correct in part 1 was also reduced to this same ratio. Correlation coefficients between the Thorndike and Lorge ratios (T & L), the experimental ratios (ER), and the times picked ratios (TIMES) were calculated and are presented in Table 5.

TABLE 5

CORRELATION OF THORNDIKE AND LORGE, EXPERIMENTAL, AND TIMES PICKED RATIOS FOR HD AND LD WORD PAIRS

VARIABLES	HD	LD
T & L vs. ER	.213	.205
T & L vs. TIMES	.217	.177
ER vs. TIMES	-.012	.479

Of interest here is the difference in the coefficients between the HD group (-.012) and the LD group (.479) for ER vs. TIMES. The HD coefficient indicated that there was effectively no explained variance between the experimental

TABLE 3

FREQUENCY RATIOS FOR MASTER LISTS OF HIGH DIFFERENTIAL WORD PAIRS

(The frequencies have been normalized with the second word in each pair, the less frequent one according to the Thorndike and Lorge count, having a base value of 10.)

ITEM	WORDS	THORNDIKE & LORGE COUNT	SUBJECTS' RATING	NO. TIMES PICKED AS CORRECT
1.	pearl jade	118	25.15	6.40
2.*	hour era	71	146.93	7.83
3.*	mile meter	83	82.66	11.58
4.	ale sherry	65	8.83	11.58
5.	journal essay	71	8.77	7.08
6.*	sugar spices	59	44.70	5.19
7.*	murder treason	67	95.55	17.33
8.*	snow gale	67	39.85	27.27
9.	porch lobby	62	9.52	11.58
10.*	juice malt	93	51.77	19.29
11.*	eagle falcon	54	34.13	31.00
12.*	boat sled	125	51.64	92.50
13.	balloon crayon	85	9.51	31.00

TABLE 3 (CONTINUED)

ITEM	WORDS	THORNDIKE & LORGE COUNT	SUBJECTS' RATING	NO. TIMES PICKED AS CORRECT
14.	ferry sailboat	55	3.42	1.71
15.	boots sandals	74	19.61	31.00
16.*	cotton tweed	143	38.33	7.83
17.	pan saucer	71	19.81	19.29
18.*	church shrine	67	51.27	14.21
19.*	grape melon	68	21.98	8.64
20.*	bee moth	56	22.23	58.33
21.*	dog moose	125	116.20	19.29
22.	poem poster	100	6.28	15.62
23.*	hair wrist	59	35.82	12.78
24.*	tent shack	71	21.06	21.54
25.*	oil steam	50	31.51	8.26

* Word pairs selected for experiment 2.

TABLE 4

FREQUENCY RATIOS FOR MASTER LIST OF LOW DIFFERENTIAL WORD PAIRS

(The frequencies have been normalized with the second word in each pair, the less frequent one according to the Thorndike and Lorge count, having a base of 10.)

ITEM	WORDS	THORNDIKE & LORGE COUNT	SUBJECTS' RATING	NO. TIMES PICKED AS CORRECT
1.	lawyer banker	17	24.39	14.12
2.*	nail bench	11	21.91	5.19
3.	foot nose	10	32.95	5.19
4.	velvet canvas	15	6.91	17.33
5.*	tin ore	20	22.93	7.08
6.	copper carbon	20	7.56	31.00
7.*	cabin barn	11	16.03	41.25
8.*	peach pear	14	13.62	15.62
9.*	chair lamp	20	23.30	15.62
10.*	maple elm	11	19.48	31.00
11.	lily daisy	12	5.30	12.78
12.*	bean rice	12	12.94	7.83
13.	cliff cave	12	9.69	12.78

TABLE 4 (CONTINUED)

ITEM	WORDS	THORNDIKE & LORGE COUNT	SUBJECTS' RATING	NO. TIMES PICKED AS CORRECT
14.	wood water	10	3.37	7.08
15.	priest bishop	11	32.82	5.19
16.*	sauce herbs	19	23.80	7.08
17.*	mayor sheriff	10	19.45	12.78
18.*	chain whip	12	22.74	27.27
19.*	sword spear	12	17.92	35.56
20.*	mirror couch	16	16.17	9.52
21.	temple chapel	20	3.72	2.81
22.*	deer fox	14	25.90	21.54
23.*	bronze zinc	19	18.80	35.56
24.	wife aunt	20	79.09	58.33
25.*	ruby opal	14	21.10	17.33

* Word pairs selected for experiment 2.

ratios and the times picked ratios while the LD coefficient indicated that a significant portion (22.9%) of the variance was explained for that group. The other four coefficients all indicated a small amount (4%) of explained variance.

Table 6 contains comparison data from experiment 1 for both the HD and LD groups. No significant difference in any category was observed between the HD and LD groups. Noteworthy here is item 5 of the table, the number of pairs in which the H word according to Thorndike and Lorge was perceived as still being the H word during part 2 of the experiment. The number was identical for both the HD and LD cases. This tended to indicate that the S's were able to make perceptions on either group with equal facility.

TABLE 6

Comparison of Choice Frequencies for HD and LD Word Pairs*
(n = 1025 for both HD and LD words)
(n = 25 for both HD and LD pairs)

ITEM	HD	LD
1. No. times H word (T & L) picked as correct	595	597
2. No. times H word (ER) picked as correct	595	575
3. No. pairs H word (T & L) picked more frequently	17	16
4. No. pairs H word (ER) picked more frequently	15	14
5. No. pairs H word (T & L) perceived as H word (ER)	19	19
6. No. times 1st word in pair picked as correct	519	530
7. No. pairs 1st word picked more frequently	13	11

* (T & L) refers to Thorndike and Lorge count
(ER) refers to experimental ratio obtained in part 2

The theoretical amount of joint uncertainty remaining after trial 1 for both the HD and LD lists was calculated from the data obtained in part 1. Using the procedures described in the word list section of the method part of experiment 2, 16 word pairs from the 25 in each master list were chosen for use in experiment 2. The average percentage with which the H words and L words in these pairs were chosen in part 1 was entered in Figure 1.

RESPONSE CATEGORY		WORD FREQUENCY	
		HIGH	LOW
a.	CORRECT	.607	0
	INCORRECT	0	.393
b.	CORRECT	.602	0
	INCORRECT	0	.398

FIGURE 1. A Priori Joint Probabilities of Word Frequency and Response Category for HL Trials from Part 1, Experiment 1 for (a) HD and (b) LD Lists. (Matrices for LH trials can be formed by moving H word percentages to incorrect response and moving L word percentages to correct response.)

The joint uncertainty for the HD list was calculated to be 15.4368 while the joint uncertainty for the LD list was 15.5360. The negligible difference (0.0992 bits) between the lists indicated that neither list provided an advantage over the other. Thus for experiment 2, the S's would have identical starting positions for both lists.

III. EXPERIMENT 2

A. METHOD

1. Word Lists

Two 16 item word lists were constructed from the 25 item master lists used in experiment 1. Only those 19 pairs in each group in which the S's of experiment 1 had rated the H word according to Thorndike and Lorge as still being the H word were considered for use in experiment 2. A third ratio was then formed for each pair by dividing the experimental ratio by the Thorndike and Lorge ratio (ER/T&L). For the HD group, the 16 pairs with the highest ER/T&L values were chosen for experiment 2. For the LD group, the 16 pairs with the lowest ER/T&L values were selected. These two sets of 16 items formed the master lists of experiment 2. The selected word pairs are shown in Tables 3 and 4 where they are designated by an asterisk.

The correct responses for the HL and LH trials of both the HD and LD lists were automatically determined by the relative frequency in the word pairs. LH-HL lists were not formed as previous experiments (Kausler and Farzanegan, 1969, Nappi, 1971) have already shown these to be significantly more difficult than either HL or LH.

2. Design

The basic experiment conformed to a three-factor mixed design with repeated measures on one factor (trials)

and two independent, factorially combined factors, frequency differential (HD vs. LD) and correct response category (HL vs. LH). The experiment was designed to evaluate the learning differential that might exist between HD-HL, HD-LH, LD-HL, and LD-HL verbal discrimination lists. These four types of VD lists were the experimental conditions that comprised the between-subjects effects. Trials and the trials x conditions were within-subjects effects. Additionally, four random variations of the HD and LD master lists were constructed to reduce cues by position. The evaluation of the effect of list variation was of a treatments-by-subjects design.

3. Subjects

The 48 subjects were graduate level students at the U.S. Naval Postgraduate School. They were all volunteers and were randomly assigned to the four treatment groups.

4. Equipment and Facilities

The experiment was conducted in a sound attenuated chamber in order to minimize external interference. The word lists were presented on a Lafayette high speed memory drum at a cycle speed of 2.0 seconds.

5. Procedure

Each subject was tested individually and all results were recorded. A set of instructions (Appendix B) was read and a demonstration of the experimental apparatus was conducted. Each verbal discrimination item was presented for 2.0 seconds followed by a 2.0 second interitem interval.

At the end of each trial, a six second intertrial break was given the subject. Correct responses were reinforced by the word "Correct" from the experimenter; incorrect responses were not reinforced. Each subject was presented the four variations of his particular VD learning list twice for a total of eight trials. After every third subject, the starting position on the memory drum tape was rotated to a new list variation.

B. RESULTS

The data obtained in experiment 2 will first be analyzed using the number of correct responses as the basis for evaluation. A summary of the number of correct responses by trial is presented in Table 7 for both the HD and LD lists. The number of subjects run under each condition was 12. The total possible number of correct responses for each trial was 192. Figure 2 graphically displays the growth in the percentage of correct responses over the eight trials for the four different conditions. The HD-LH and LD-LH curves indicated a fairly smooth increase in the number of correct responses over the trials and showed no evidence of the sudden jump found by Nappi (1971).

The starting positions on the memory drum tapes had been rotated after every third subject in order to determine if a particular sequencing of the VD pairs had any effect on the number of correct responses. The summation of the total correct for each variation of the four conditions is presented in Table 8.

TABLE 7

UMMARY DATA FOR EXPERIMENT 2

TRIALS							
1	2	3	4	5	6	7	8
105	133	155	173	180	184	190	190
.547	.693	.807	.901	.938	.958	.990	.990
8.75	11.08	12.92	14.42	15.00	15.33	15.83	15.83
4.02	6.81	2.45	2.08	1.82	.97	.15	.33
91	127	141	150	169	178	182	185
.474	.661	.734	.781	.880	.927	.948	.964
7.58	10.58	11.75	12.50	14.08	14.83	15.17	15.42
6.08	6.63	7.66	7.36	3.72	1.42	.52	.63
99	121	150	163	170	171	182	187
.156	.630	.781	.849	.885	.891	.948	.974
8.25	10.08	12.50	13.58	14.17	14.25	15.17	15.58
4.93	3.36	4.82	3.90	3.06	3.48	1.06	.63
103	112	127	148	157	166	175	176
.536	.583	.661	.771	.818	.866	.911	.917
8.58	9.33	10.58	12.33	13.08	13.83	14.58	14.67
5.72	4.79	4.99	4.97	3.36	5.79	3.90	2.79

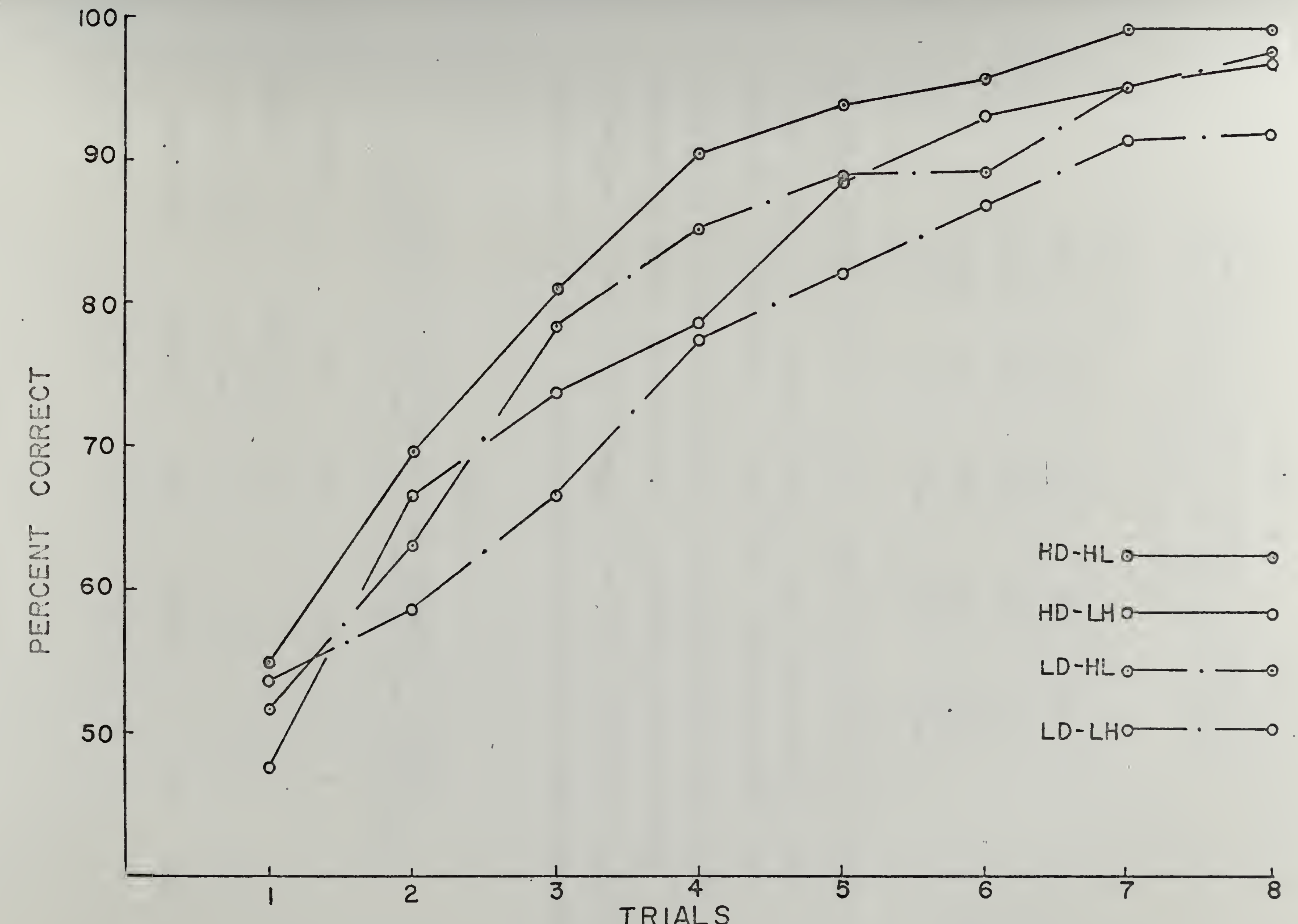

Figure 2. Percent Correct Responses by Trial

TABLE 8

SUMMATION OF TOTAL CORRECT RESPONSES BY LIST VARIATION FOR THE FOUR CONDITIONS

	LIST VARIATION			
CONDITION	1	2	3	4
HD-HL	328	321	332	329
HD-LH	308	300	307	306
LD-HL	301	306	312	313
LD-LH	282	288	305	299

Using complete subject by list variation tables of correct responses, an analysis of variance was conducted for each condition to determine if there was a difference in the number of correct responses for the different variations. Table 9 presents the analysis of variance for the HD-HL condition. The other three analyses also indicated a similar lack of criticality in the order in which pairs were presented.

TABLE 9

ANALYSIS OF VARIANCE OF THE NUMBER OF CORRECT RESPONSES BY LIST VARIATION FOR THE HD-HL CONDITION

SOURCE	SS	df	MS	F	P
TOTAL	552.00	47	-	-	-
VARIATION	5.42	3	1.81	0.16	n.s.
SUBJECTS	173.42	11	15.77	1.39	$<.25$
ERROR	373.16	33	11.31	-	-

The F statistic of 0.16 for variation indicated no significance in the effect of list variation. The F statistic of 1.39 for subjects would be critical at =.25 but not at any lower significance level.

To analyze the complete set of correct responses, an analysis of variance was conducted on the data. The purpose of this analysis was to evaluate learning trends as a function of frequency differential and the type of correct response. The results are presented in Table 10.

TABLE 10

ANALYSIS OF VARIANCE OF THE NUMBER OF CORRECT RESPONSES

SOURCE	SS	df	MS	F	P
Between Subjects	706.96	47	-	-	-
HD-LD	41.34	1	41.34	3.06	$<.10$
HL-LH	71.76	1	71.76	5.31	$<.05$
HD-LD x HL-LH	0.17	1	0.17	0.01	n.s.
error_b	593.69	44	13.49	-	-
Within Subjects	2852.00	336	-	-	-
trials	2144.79	7	306.40	142.45	$<.001$
trials x HD-LD	15.90	7	2.27	1.05	n.s.
trials x HL-LH	18.16	7	2.59	1.20	n.s.
trials x HD-LD x HL-LH	10.67	7	1.52	0.70	n.s.
error_w	662.48	308	2.15	-	-
Total	3558.96	383	-	-	-

The conditions of HD-LD and HL-LH formed the between-subjects effects. The trials and the trials x conditions formed the within-subjects effects. As could be expected, the effects of trials was highly significant (F=142.45), but none of the interactions involving trials was significant at any meaningful level. Of the between-subjects main effects, only the HL-LH effect was significant at the .05 level. The interaction was not significant.

Considering the controls exercised in the experiment, the significance of the HD-LD conditions at the .10 level would have to be considered marginal. Whether the HD results are different from the LD results would depend on what significance level the experimenter chose as his criterion and on whether the results could be replicated in another experiment. In contrast to the findings of Nappi (1971) and Kausler and Farzanegan (1969), the HL and LH conditions were found to be significant in this experiment. The HL lists were easier to learn than the LH lists.

Considering the differences found between this experiment and previous ones, it was thought possible that significant rule learning might have taken place during the first trial and therefore did not show up later. This would at least partially account for the absence of jump effect learning as it occurred in Nappi's experiment. Therefore, the results of the first trial of each of the conditions were analyzed to determine if any trend by word position occurred. For analytic purposes, two adjacent word pairs were grouped

together to form one unit. The percent correct responses for the resulting eight groups is presented in Figure 3. With the exception of the LD-LH condition, there were wide variations within each condition in percent correct for the different groups. Only in the LD-LH case did the curve level off after an early rise and then remain fairly constant.

The percentage of correct answers for the first trial as predicted by experiment 1 did not materialize in experiment 2. Table 11 gives the expected and actual values of percent correct and joint uncertainty for trial 1.

TABLE 11

EXPECTED AND ACTUAL VALUES OF PERCENT
CORRECT AND JOINT UNCERTAINTY OF TRIAL 1

	EXPECTED		ACTUAL	
CONDITIONS	PERCENT	JOINT UNCERT.	PERCENT	JOINT UNCERT.
HD-HL	.607	15.4368	.547	15.8976
HD-LH	.393	15.4368	.474	15.9696
LD-HL	.602	15.5360	.516	15.9856
LD-HL	.398	15.5360	.536	15.9376

For the HL conditions, the actual percent correct is less than expected and for the LH, higher. With respect to the LH results, it would appear that instantaneous feedback to the S of his performance increases the likelihood of picking a correct response. In the HL case, however, it would appear that feedback hinders performance initially. In all cases

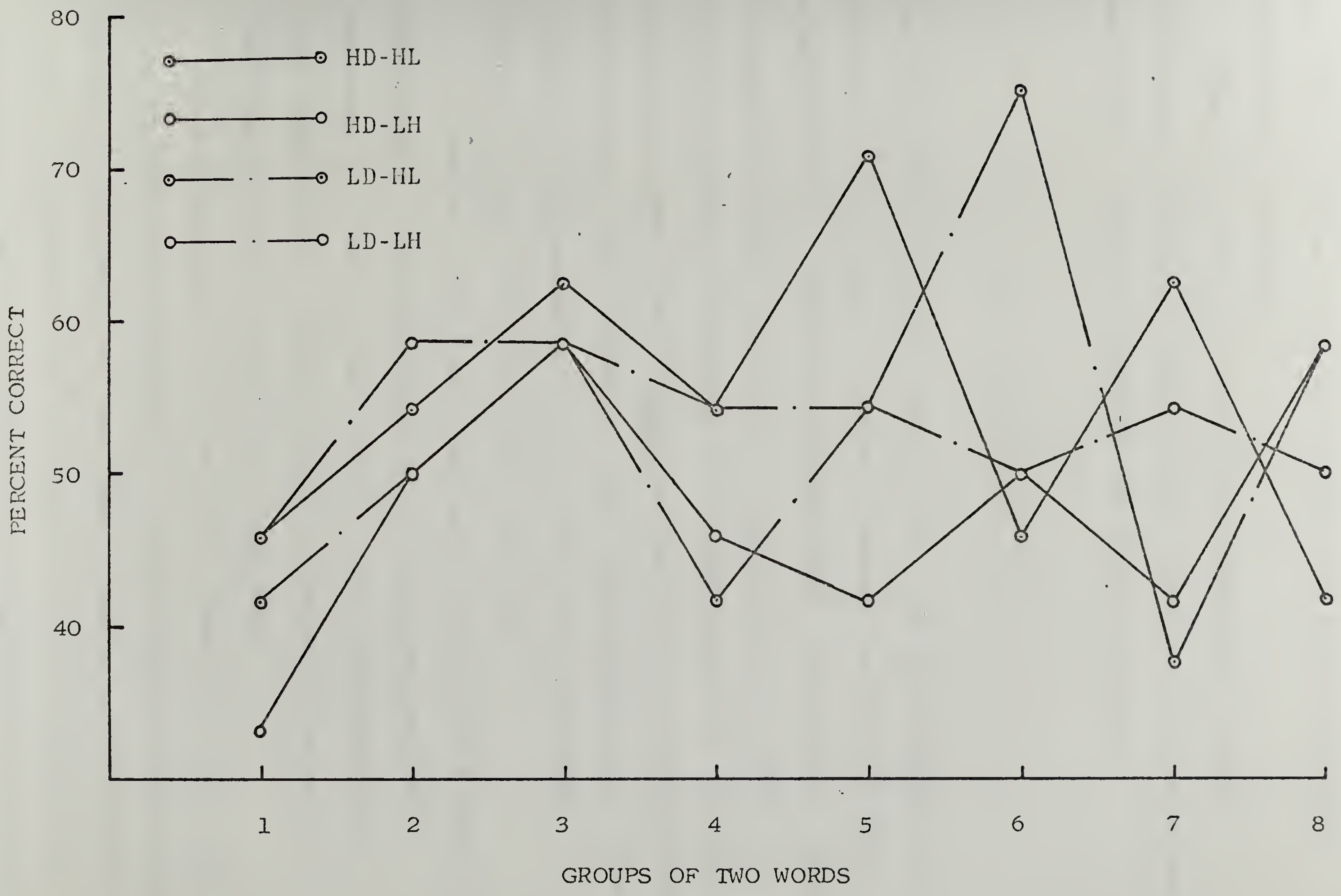

Figure 3. Percent Correct Responses by Word Position on Trial 1

the actual joint uncertainty was higher than expected and was not significantly different from the maximum possible uncertainty of 16 bits.

Underwood and Freund (1970) considered six trials sufficient to observe trends in the results. This experiment used eight. Figure 4 presents the sample variance,

$$S^2 = \frac{1}{n-1} \sum (X_i - \bar{X})^2 ,$$

for each trial of the HD and LD lists. By the seventh trial, variance in the number of correct answers had all but disappeared for all conditions except LD-LH. This result tended to support the use of only six trials instead of eight. A one-way analysis of variance of the performance of the four conditions summed over six trials resulted in a nonsignificant F-statistic at the .05 level. This also suggested that the results of the preceding analyses would not have been different if only six trials had been used.

Information theory was also used to analyze the data of experiment 2. The percentage of correct and incorrect responses by trial for each subject was transformed into joint uncertainty. Table 12 gives the total uncertainty remaining by trial for the four conditions.

The average amount of uncertainty remaining after each trial is presented in Figure 5. A three factor mixed design analysis of variance was then used to evaluate the decrease in joint uncertainty over the trials as a function of the experimental conditions. Results are presented in Table 13.

TABLE 12
TOTAL UNCERTAINTY REMAINING BY TRIAL

CONDITIONS	TRIALS							
	1	2	3	4	5	6	7	8
HD-HL	181.0240	153.5280	125.5808	76.8624	48.6144	35.6336	10.4768	8.6960
HD-LH	177.7296	158.7872	136.8144	117.1408	82.5872	58.0096	48.8334	33.1072
LD-HL	181.7552	174.7552	128.5744	97.9200	81.1228	76.0384	66.3296	22.6304
LD-LH	179.4848-	117.6112	166.0416	134.0848	116.4368	85.9248	58.6464	58.8832

TABLE 13
ANALYSIS OF VARIANCE OF THE UNCERTAINTY REMAINING AT EACH TRIAL

SOURCE	SS	df	MS	F	P
Between Subjects	3742.4232	47	-	-	-
HD-LD	283.2967	1	283.2967	3.9550	<.10
HL-LH	307.3931	1	307.3931	4.2914	<.05
HD-LD x HL-LH	0.0338	1	0.0338	0.0005	n.s.
error_b	3151.6996	44	71.6295	-	-
Within Subjects	10845.6240	336	-	-	-
trials	7422.8640	7	1040.4091	101.8997	<.001
trials x HD-LD	60.7199	7	8.6743	0.8336	n.s.
trials x HL-LH	101.4961	7	14.4994	1.3933	n.s.
trials x HD-LD x HL-LH	55.3620	7	7.9089	0.7600	n.s.
error_w	3205.1820	308	10.4064	-	-
Total	14588.0472	383	-	-	-

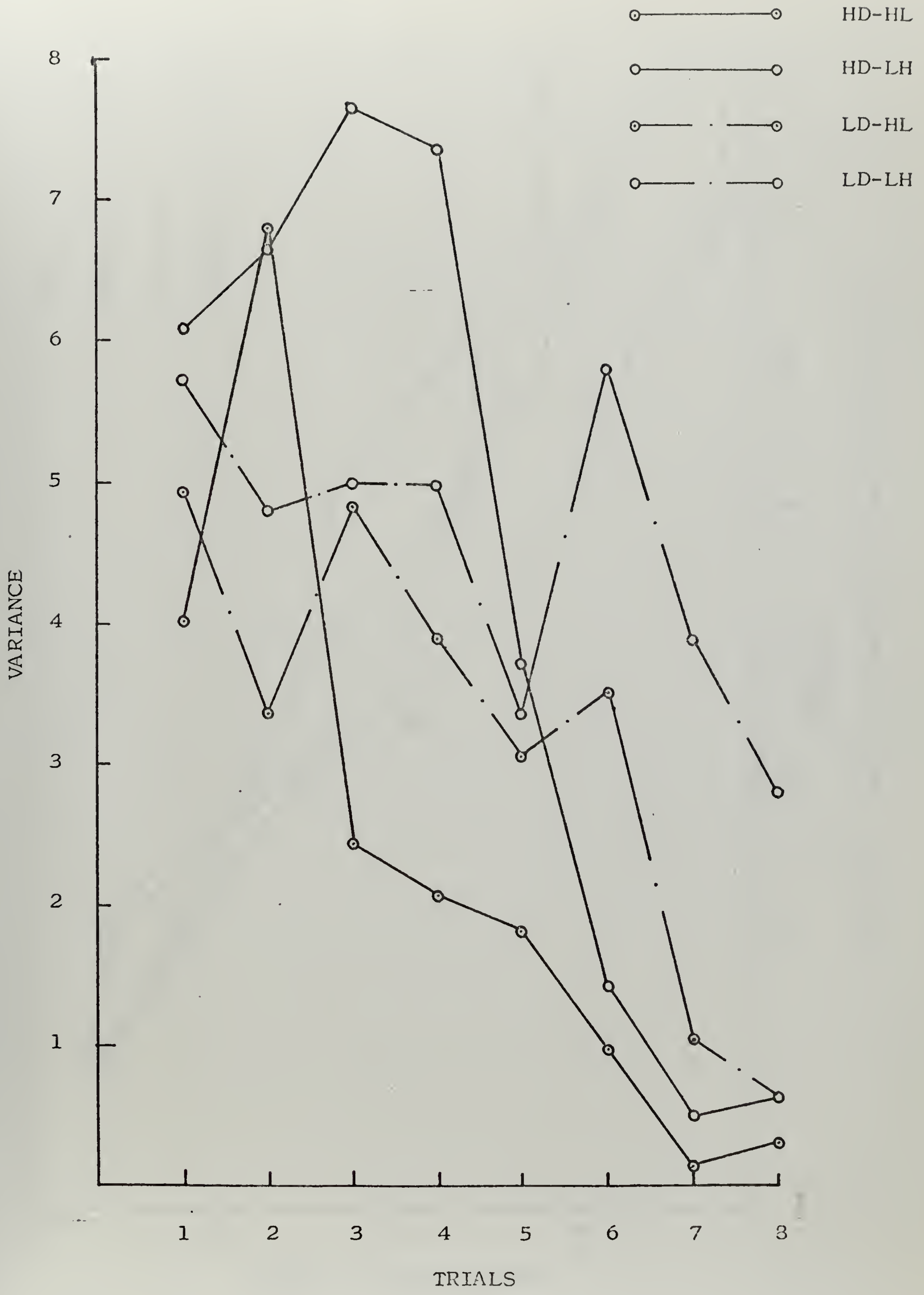

Figure 4. Sample Variance by Trial

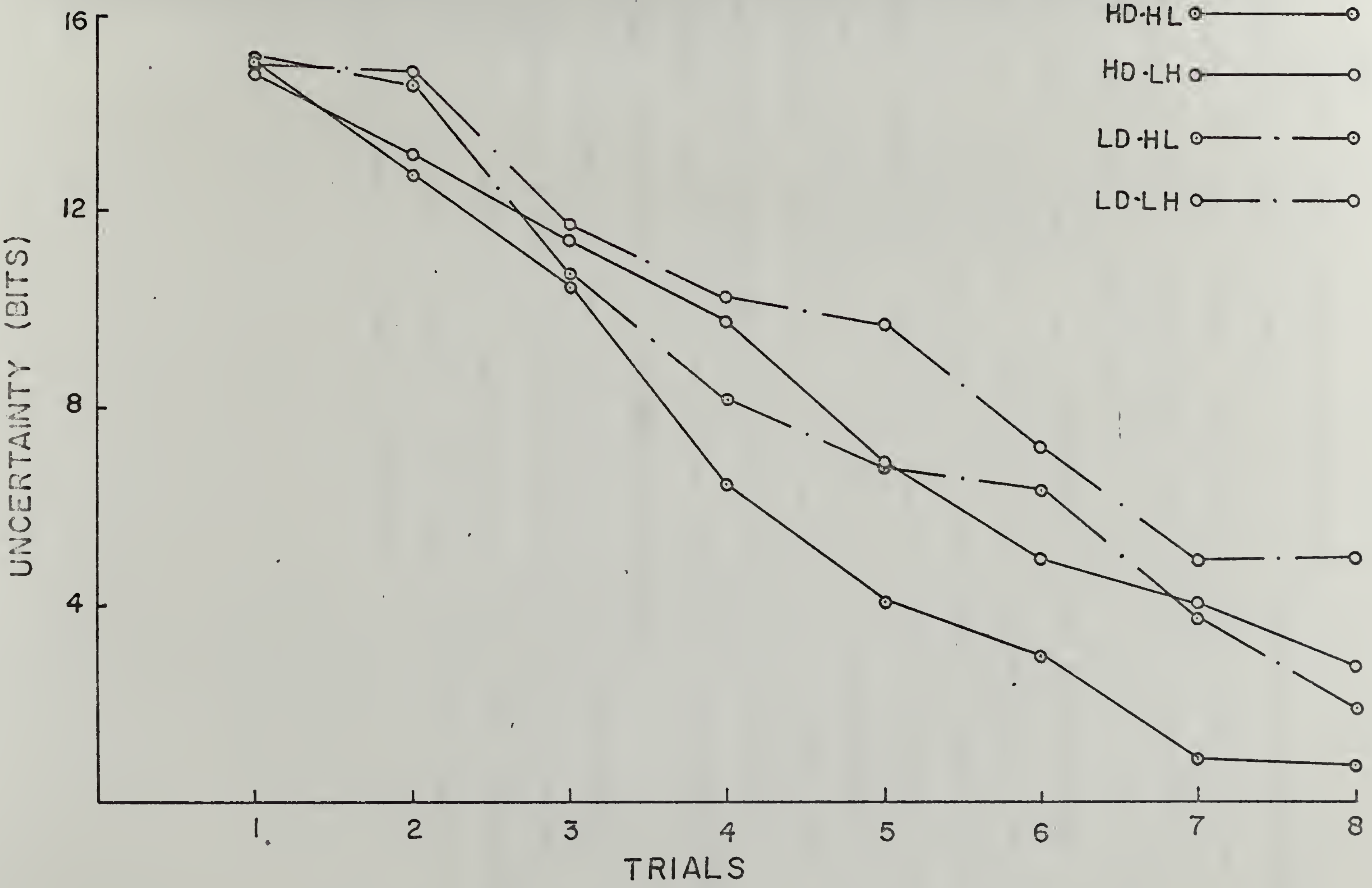

Figure 5. Average Uncertainty Remaining by Trial

Superficially, the results appeared to be identical to the results obtained from the analysis of variance on the number of correct responses. The most significant difference between the two, however, was in the F-statistics for the HD-LD condition. The critical value of the F-statistic at the .05 level of significance is 4.06. In the analysis of the number correct, the experimental value for HD-LD was F=3.06, significantly lower than 4.06. However, in the analysis using joint uncertainty, the experimental value was F= 3.955. While this F-statistic was not critical at the .05 level of significance, it was critical at approximately the .06 level. Thus, in the joint uncertainty analysis, the HD-LD condition became more statistically significant. Further experimentation would be required to determine the exact significance of the HD-LD condition.

A decrease in the F-statistic from 5.31 for correct response to 4.2914 for joint uncertainty was also noted for the HL-LH conditions. Both statistics are still significant at the .05 level, however. All other results in the two analyses remain virtually identical.

IV. DISCUSSION

This study demonstrated that S's were able to differentiate between words with HD and LD verbal discrimination pairs with apparent equal facility. Nappi (1971) had suggested that a possible fruitful area for study would be the examination of the threshold at which relative background frequencies become significant. The results of the study tended to indicate that the threshold is surprisingly low. Two observations can be made about the results of this study. They are: (a) the subjects were able to distinguish background frequency differentials equally well whether they were 10 to 1 or 2 to 1, and (b) most subjects apparently used methods other than rule learning to memorize the lists. The experimentor talked with each of the 48 subjects of experiment 2 after the completion of their runs. Only three stated that they had consciously used frequency differential as the cue for choosing words. The others stated that initially, they had used various other methods in trying to learn the lists (see figures 2 and 5), but that after a few trials they basically began to use rote memorization. One of the premises of frequency theory is that rule learning can be done subconsciously. It was impossible to tell for how many of these other 45 that this was the case.

The few S's who learned the lists quickly contributed heavily to the differences found between the conditions. Once an S gave all correct responses to the list, he usually completed the remaining trials without a mistake. Thus an

S who learned the lists early would have a particularly strong influence on the summary data over the next few trials before the other S's began to learn. If several more S's had learned the lists by the second or third trial, the results might nave been considerably altered. Table 14 shows the number of subjects who attained 16 correct responses for the first time by trial.

TABLE 14

NUMBER OF SUBJECTS ATTAINING 16 CORRECT RESPONSES FOR THE FIRST TIME BY TRIAL

CONDITION	TRIALS								NEVER LEARNED
	1	2	3	4	5	6	7	8	
HD-HL	0	0	1	1	4	1	3	2	0
HD-LH	0	1	0	2	1	3	0	2	3
LD-HL	0	0	1	2	0	1	2	3	3
LD-LH	0	0	0	1	2	0	3	1	5
TOTAL	0	1	2	6	7	4	8	8	11

Both the F-statistics obtained from the analysis of variance of correct responses and the analysis of variance of joint uncertainty for the HD-LD conditions were critical in the range between .05 and .10 level of significance. The statistic for joint uncertainty was particularly close to the critical value at the .05 level. While the .05 level is generally used for controlled laboratory experiments such as this one, the range between .05 and .10 should at best be considered equivocal. Thus, considering the F-statistics

obtained in experiment 2, it would appear that further experimentation would be required before an inference could be made on the exact significance or insignificance of the HD-LD conditions.

One aspect of this study that differed substantially from the results of Nappi (1971) and Kausler and Farzanegan (1969) was the significance of the HL-LH conditions. Neither of these two previous studies had found any significant difference in the learning rates of HL or LH lists. Frequency theory does state, however, that the learning of the HL list should be more efficient, and the present study found this to be true. A decrease in the F-statistic for the HL-LH conditions was found in the analysis of variance for joint uncertainty when compared to the analysis of variance for correct responses. Whether this decrease supports the hypotheses of rule learning is equivocal, but it was assumed that, where differences might occur in correct responses as a function of the high- or low-frequency word being correct, the information measure should show negligible differences if rule learning took place.

One of the stated purposes of experiment 2 was to examine the jump effect found in the LH list by Nappi's experiment. No such jump was evident in the present experiment for either of the LH conditions (see Figure 2). An examination of the first trial to determine if a trend in learning had occurred early enough to preclude a later jump revealed nothing of significance. Quite possibly the jump in correct responses

after the third trial in Nappi's LH list was caused by idiosyncratic differences in either the word list or the subjects.

A surprising result was the lack of consistency between experiment 1 and experiment 2 in the number of H words picked on the first trial. Part 1 of experiment 1 had predicted that in experiment 2, the H word would be chosen approximately 60% of the time on trial 1 for both the HD and LD lists. The actual percentages were scattered around the 50% level. Taken in conjunction with the conversations held with each S, this indicated a rapid switching among hypotheses by the S's in an attempt to find one which would be the cue to the correct response. This erratic behavior, evidenced by large fluctuations in percent correct responses by word position, was more prevalent in the HL lists than in the LH lists (see Figure 3). The net effect was to produce almost complete randomization of choices on the first trial. The actual joint uncertainty of trial 1 was not significantly different from the maximum possible uncertainty for all conditions.

The premise of Underwood and Freund (1970) that six trials are sufficient to produce a trend in results was reaffirmed by this study. Both a one-way analysis of variance after six trials and a trend analysis over trials of the variance in correct responses indicated that there was no significant change in results from the sixth to the eighth trials.

V. SUMMARY

In this study, two experiments were conducted to examine the effects of two background frequency differentials on verbal discrimination learning. Two 25 item master lists were constructed. In the high differential (HD) list were word pairs in which the relative background frequency of the two words in each pair was at least 5 to 1. The low differential (LD) list was made up of word pairs in which the frequency differential was 2 to 1 or less. Experiment 1 was conducted to determine the 16 best pairs in each list. Experiment 2 then used these best pairs to investigate difference in learning rates between the HD and LD conditions. High frequency word correct (HL) and low frequency word correct (LH) conditions were also examined. Results were evaluated not only on the number of correct responses, but also on the uncertainty remaining after each trial. The HL word lists were found to be significantly easier to learn than the LH word lists. This result was contrary to what has been found in several past experiments. No significant difference was found between the HD and LD conditions at the .05 level. However, they were significant at the .10 level. This would tend to indicate that further research into the HD and LD conditions will be necessary before a positive statement can be made on the significance of these conditions.

Overall, it can be stated that the background frequency of words does influence VD learning such that learning appears to be faster with high differential frequencies in word pairs and when the more frequent member is designated the correct response. These effects are not great, however, except in the case of those subjects who consciously or subconsciously use the frequency differential as a cue.

APPENDIX A

SUBJECTS' INSTRUCTIONS FOR EXPERIMENT 1

Turn to page 1, but please do not go any farther. On pages 1 and 2 are 50 pairs of words. One word in each pair has arbitrarily been chosen as correct. Your task is to try to pick which one and circle it. When finished with page 2 do not, repeat, do not go to page 3. Are there any questions?

Now turn to page 3. Once again, on pages 3 and 4, are 50 pairs of words. This time your task is to rate each word in the pair according to its relative frequency of usage in the English language The word you feel has a lower frequency of usage will always be given a value of 10. The higher frequency word will be given a value which you feel is its relative frequency to the lower word. For example, take the words "motor" and "tree". If you think "tree" is $4\frac{1}{2}$ times more common than "motor", then you would enter

motor 10
tree 45 .

In some pairs you may feel the words are equal in usage. In such a case, each word would get a value of 10. Do not refer back to pages 1 and 2 during this part of the task. Are there any questions?

APPENDIX B

SUBJECTS' INSTRUCTIONS FOR EXPERIMENT 2

You are about to participate in a verbal discrimination experiment. You will be shown a list of 16 word pairs, one pair at a time. One word in each pair has arbitrarily been chosen as correct by the experimenter. On the initial pass through the list, you will not know which word is the correct one, but will have to guess. Announce your choice to the experimenter and he will tell you if it is correct. If it is not correct, no reply will be given.

The list of 16 word pairs will be presented 8 times, each time in a different order. While the same two words will always make up a pair, their order in the pair may change. The correct response for each pair will always remain the same however. The words will appear on the screen for 2 seconds and then the screen will go blank for 2 seconds before the next words appear. During these 4 seconds you must select the correct word and say it aloud to the experimenter. A blank interval of approximately 6 seconds will appear when the list is going to repeat.

Your task throughout this experiment will be to give as many correct responses as you can. Please pay strict attention to the screen as you may easily become distracted. Upon completion of the experiment, please do not discuss it with anyone who might also be a subject.

Do you have any questions?

Thank you.

APPENDIX C

CORRECT RESPONSES OVER TRIALS BY SUBJECT

HD-HL CONDITION

-- TRIALS

	1	2	3	4	5	6	7	8
1.	8	9	13	13	16	16	16	16
2.	9	10	13	15	16	16	16	16
3.	8	5	12	11	13	14	15	16
4.	8	12	14	15	15	16	16	16
5.	14	14	15	16	16	16	16	16
6.	6	14	12	15	14	15	16	14
7.	7	11	11	15	15	15	16	16
8.	10	14	16	16	16	16	16	16
9.	8	12	12	15	15	15	16	16
10.	10	12	12	15	16	16	16	16
11.	8	11	11	13	12	13	15	16
12.	9	9	14	14	16	16	16	16

HD-LH CONDITION

TRIALS

	1	2	3	4	5	6	7	8
1.	4	10	11	11	10	14	15	15
2.	8	9	11	14	15	16	16	16
3.	11	10	14	16	16	16	16	16
4.	6	7	11	9	14	13	15	15
5.	8	8	9	10	11	16	15	16
6.	8	10	9	12	13	16	16	16
7.	9	9	11	11	14	14	15	16
8.	9	13	14	16	15	15	14	14
9.	5	11	12	10	16	14	15	15
10.	12	16	16	16	16	16	16	16
11.	6	14	15	15	15	15	15	16
12.	5	10	7	10	14	13	14	14

LD-HL CONDITION

TRIALS

	1	2	3	4	5	6	7	8
1.	9	10	11	11	11	12	14	16
2.	7	8	13	14	14	14	15	16
3.	6	14	15	16	16	16	16	16
4.	8	9	11	11	12	10	13	14
5.	6	10	14	16	16	16	16	16
6.	5	12	16	16	16	16	16	16
7.	7	8	10	12	15	14	15	15
8.	9	11	11	12	12	14	14	16
9.	9	8	9	12	15	13	15	14
10.	10	11	15	15	15	15	16	16
11.	10	9	12	13	13	15	16	16
12.	13	11	13	15	15	16	16	16

LD-LH CONDITION

TRIALS

	1	2	3	4	5	6	7	8
1.	7	8	9	14	13	15	16	16
2.	5	9	10	13	11	12	14	13
3.	10	6	11	12	13	15	16	16
4.	13	12	13	13	16	16	16	16
5.	10	14	12	16	15	16	16	15
6.	10	10	12	10	12	11	15	15
7.	9	11	12	13	16	15	16	16
8.	10	8	7	7	11	8	10	12
9.	9	8	7	12	12	13	15	12
10.	9	10	14	12	13	15	16	16
11.	6	8	9	14	14	15	12	13
12.	5	8	11	12	11	15	13	16

APPENDIX D

UNCERTAINTY REMAINING OVER TRIALS BY SUBJECT

JOINT UNCERTAINTY
FOR HD-HL CONDITION

TRIALS

	1	2	3	4	5	6	7	8
1.	16.0000	15.8320	11.2224	11.2224	0	0	0	0
2.	15.8320	15.2704	11.2224	5.2384	0	0	0	0
3.	16.0000	12.9808	12.9808	14.2912	11.2224	8.6960	5.2384	0
4.	16.0000	12.9808	8.6960	5.2384	5.2384	0	0	0
5.	8.6960	5.2384	0	0	0	0	0	0
6.	14.2912	8.6960	12.9808	5.2384	8.6960	5.2384	0	8.6960
7.	15.8320	14.2912	14.2912	5.2384	5.2384	5.2384	0	0
8.	15.2704	8.6960	0	0	0	0	0	0
9.	16.0000	12.9808	12.9808	5.2384	5.2384	5.2384	0	0
10.	15.2704	12.9808	12.9808	5.2384	0	0	0	0
11.	16.0000	14.2912	14.2912	11.2224	12.9808	11.2224	5.2384	0
12.	15.8320	15.8320	8.6960	8.6960	0	0	0	0

JOINT UNCERTAINTY
FOR HD-LH CONDITION

TRIALS

	1	2	3	4	5	6	7	8
1.	12.9808	15.2704	14.2912	14.2912	15.2704	8.6960	5.2384	5.2384
2.	16.0000	15.8320	14.2912	8.6960	5.2384	0	0	0
3.	14.2912	15.2704	8.6960	0	0	0	0	0
4.	15.2704	15.8320	14.2912	15.8320	8.6960	11.2224	5.2384	5.2384
5.	16.0000	16.0000	15.8320	15.2704	14.2912	0	5.2384	0
6.	16.0000	15.2704	15.8320	12.9808	11.2224	0	0	0
7.	15.8320	15.8320	14.2912	14.2912	8.6960	5.2384	0	0
8.	15.8320	11.2224	5.2384	0	5.2384	5.2384	8.6960	0
9.	14.2912	14.2912	12.9808	15.2704	0	8.6960	5.2384	5.2384
10.	12.9808	0	0	0	0	0	0	0
11.	15.2704	8.6960	5.2384	5.2384	5.2384	5.2384	5.2384	0
12.	12.9808	15.2704	15.8320	15.2704	8.6960	11.2224	8.6960	8.6960

JOINT UNCERTAINTY
FOR LD-HL CONDITION

TRIALS

1.	15.8320	15.2704	14.2912	14.2912	14.2912	12.9808	8.6960	0
2.	15.8320	16.0000	11.2224	8.6960	8.6960	8.6960	5.2384	0
3.	15.2704	8.6960	5.2384	0	0	0	0	0
4.	16.0000	15.8320	14.2912	14.2912	12.9808	15.2704	11.2224	8.6960
5.	15.2704	15.2704	8.6960	0	0	0	0	0
6.	14.2912	12.9808	0	0	0	0	0	0
7.	15.8320	16.0000	15.2704	12.9808	5.2384	8.6960	5.2384	5.2384
8.	15.8320	14.2912	14.2912	12.9808	12.9808	8.6960	8.6960	0
9.	15.8320	16.0000	15.8320	12.9808	5.2384	11.2224	5.2384	8.6960
10.	15.2704	14.2912	5.2384	5.2384	5.2384	5.2384	0	0
11.	15.2704	15.8320	12.9808	11.2224	11.2224	5.2384	0	0
12.	11.2224	14.2912	11.2224	5.2384	5.2384	0	0	0

JOINT UNCERTAINTY FOR LD-LH CONDITION

TRIALS

	1	2	3	4	5	6	7	8
1.	15.8320	16.0000	15.8320	8.6960	11.2224	5.2384	0	0
2.	14.2912	15.8320	15.2704	11.2224	14.2912	12.9808	8.6960	11.2224
3.	15.2704	15.2704	14.2912	12.9808	11.2224	5.2384	0	0
4.	11.2224	12.9808	11.2224	11.2224	0	0	0	0
5.	15.2704	8.6960	12.9808	0	5.2384	0	0	5.2384
6.	15.2704	15.2704	12.9808	15.2704	12.9808	14.2912	5.2384	5.2384
7.	15.8320	14.2912	12.9808	11.2224	0	5.2384	0	0
8.	15.2704	16.0000	15.8320	15.8320	14.2912	16.0000	15.2704	12.9808
9.	15.8320	16.0000	15.8320	12.9808	12.9808	11.2224	5.2384	12.9808
10.	15.8320	15.2704	8.6960	12.9808	11.2224	5.2384	0	0
11.	15.2704	16.0000	15.8320	8.6960	8.6960	5.2384	12.9808	11.2224
12.	14.2912	16.0000	14.2912	12.9808	14.2912	5.2384	11.2224	0

BIBLIOGRAPHY

1. ATTNEAVE, F., "Psychological Probability as a Function of Experienced Frequency", _Journal of Experimental Psychology_, V.46, p. 81-86, 1953.

2. BATTIG, W.F., and MONTAGUE, W.E., "Category Norms for Verbal Items in 56 Categories", _Journal of Experimental Psychology_, V.80, p. 1-46, 1969.

3. COOMBS, C.H., DAWES, R.M., and TVERSKY, A., _Mathematical Psychology_, Prentice-Hall, Englewood Cliffs, N.J., 1970.

4. DIXON, W.J., and MASSEY, F.J., Jr., _Introduction to Statistical Analyses_, McGraw-Hill, New York, 1969.

5. ECKSTRAND, B.R., WALLACE, W.P., and UNDERWOOD, B.J., "A Frequency Theory of Verbal-Discrimination Learning", _Psychology Review_, V.73, p. 566-578, 1966.

6. GARNER, W.R., _Uncertainty and Structure as Psychological Concepts_, John Wiley and Sons, New York, 1962.

7. KAUSLER, D.H., and FARZANEGAN, F., "Word Frequency and Selection Strategies in Verbal-Discrimination Learning", _Journal of Verbal Learning and Verbal Behavior_, V.8, p. 196-201.

8. NAPPI, L.T., _Effect of Background Frequency of Occurrence on Difficulty of Verbal Discrimination Task_, M.S. Thesis, U.S. Naval Postgraduate School, Monterey, California, 1971.

9. SHAPIRO, B.J., "The Subjective Estimation of Relative Word Frequency", _Journal of Verbal Learning and Verbal_ Behavior, V.8, p. 248-251, 1969.

10. THORNDIKE, E.L., and LORGE, I., _The Teacher's Word Book of 30,000 Words_, Columbia University, New York, 1944.

11. UNDERWOOD, B.J., and FREUND, J.S., "Two Tests of a Theory of Verbal-Discrimination Learning", _Canadian Journal of Psychology_, V.22, p. 96-104, 1968.

12. UNDERWOOD, B.J., and FREUND, J.S., "Retention of a Verbal Discrimination", _Journal of Experimental Psychology_, V.84, p. 1-14, 1970.

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Two experiments were conducted to examine the effects of two background frequency differentials on verbal discrimination learning. Two 16 item word lists were constructed. In the high differential (HD) list were word pairs in which the relative background frequency of the two words in each pair was at least 5 to 1. The low differential (LD) list was

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made up of word pairs in which the frequency differential was 2 to 1 or less. The experiments investigated the difference in learning rates between the HD and LD conditions. High frequency word correct (HL) and low frequency word correct (LH) conditions were also examined. Results were evaluated not only on the number of correct responses, but also on the uncertainty remaining after each trial. The HD condition was found to be easier to learn than the LD at the .10 level of significance; the HL condition was significantly easier than the LH at the .05 level. Overall, the background frequency of words influenced VD learning such that learning appeared to be faster with HD word pairs in which the H word had been designated as correct.

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